



Thermal Neutron Scattering Law Benchmark and Validation at NCSU

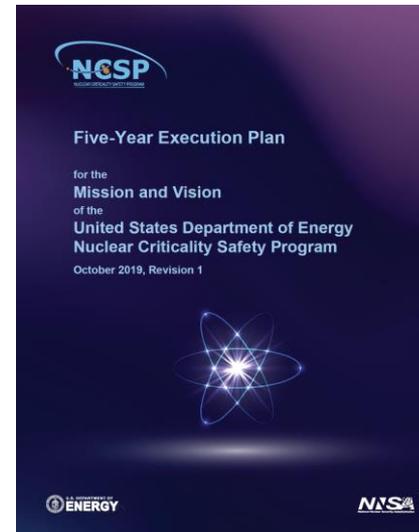
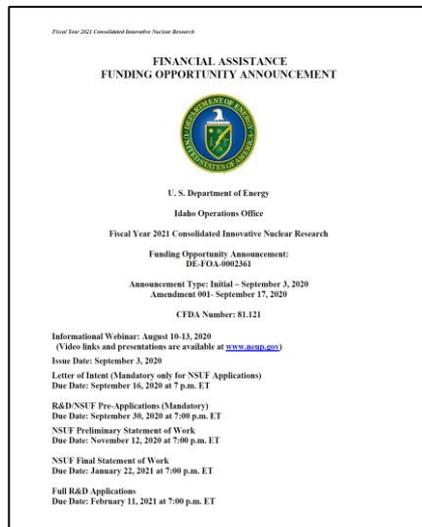
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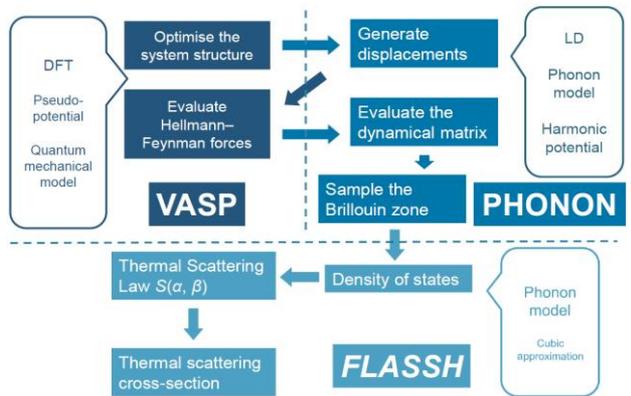
Nuclear Data Week (CSEWG-USNDP-NDAG)
November 30 – December 4, 2020

Acknowledgment

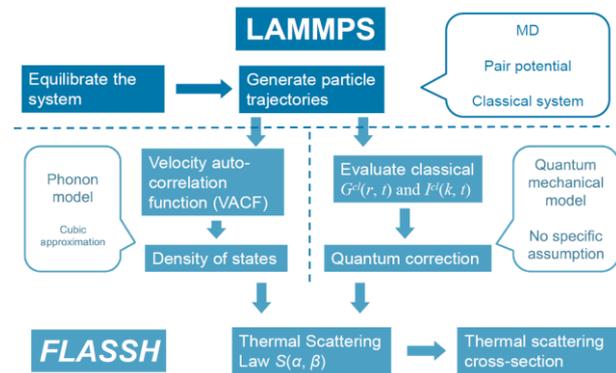
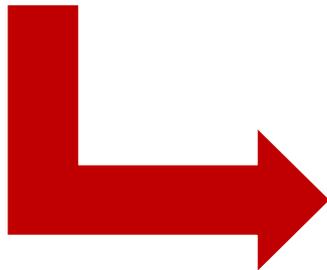
- ❑ DOE NE through the Nuclear Energy University Program (NEUP)
- ❑ NNSA Nuclear Criticality Safety Program (NCSP)
 - in collaboration with LLNL
- ❑ Naval Nuclear Propulsion Program (NNPP)



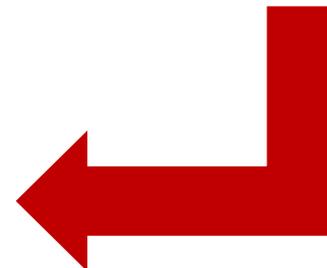
TSL Methodology



DFT/LD approach



MD approach



Crystal Structure: U_UN

Material Selection: 12 - U in UN

Parameters [a b c [Å] α β γ [°] (space group)]: 4.85945 4.85945 4.85945 90 90 90 (Fm-3m)

Input unit cell vectors a, b, and c, in the unit of Å.

	X	Y	Z
a	4.85945	0.00000	0.00000
b	0.00000	4.85945	0.00000
c	0.00000	0.00000	4.85945

Number of Non-Equivalent Atoms Sites: 2

DOS Type: Atom site

FLASSH: U_UN

Project Create Run Help

FLASSH

Full Law Analysis Scattering System Hub

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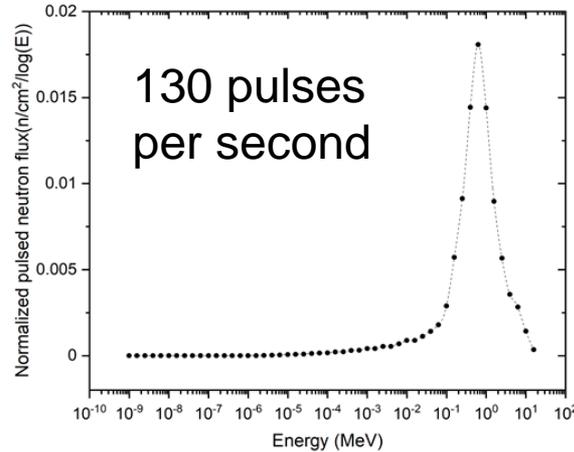
LEIP LABORATORIES

TSL Benchmark and Validation

- ❑ NCSU graphite slowing-down-time benchmark experiment
 - Performed at ORELA facility 2005-2008
- ❑ Testing of graphite TSL libraries in the PROTEUS benchmark
- ❑ Validation of the polyethylene TSL
 - Total cross section measurements
 - LLNL TEX experiments
- ❑ Validation of single crystal sapphire (Al_2O_3) TSL

Graphite

Slowing-Down-Time Benchmark



NEA/NSC/DOC(2006)1

NCSU Graphite File
ORELA Slowing-Down-Time Experiment

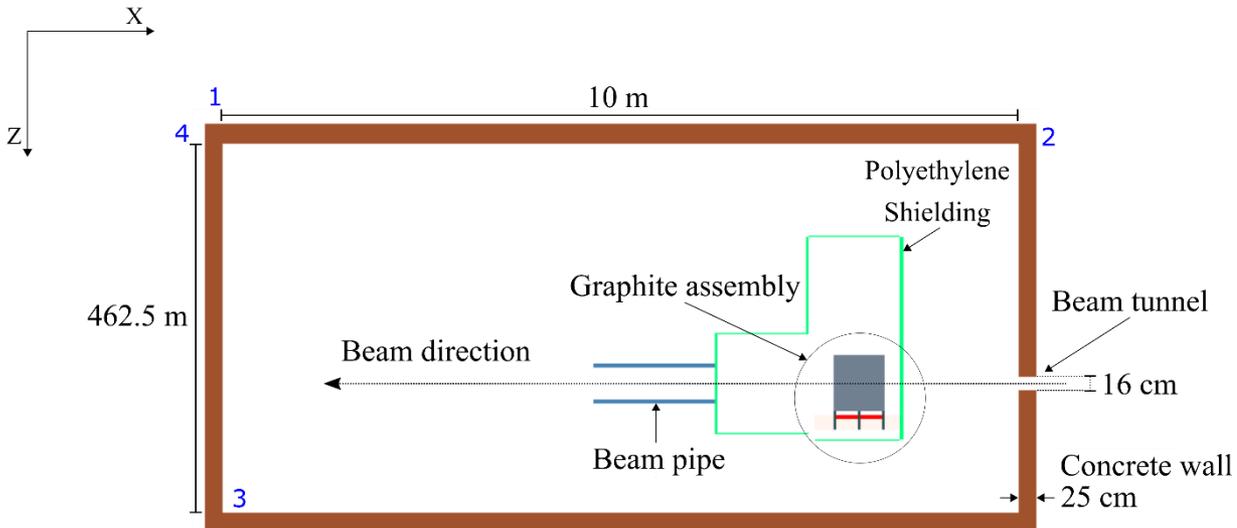
Benchmark of Neutron Thermalization in Graphite Using the Slowing-Down-Time ORELA Experiment

DRAFT

Evaluators
Eunji Lee
Nina Colby Fleming
North Carolina State University
Internal Reviewer

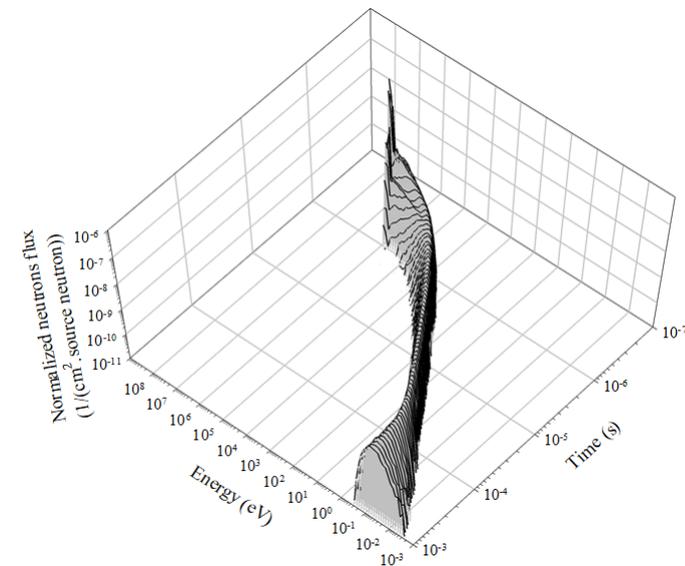
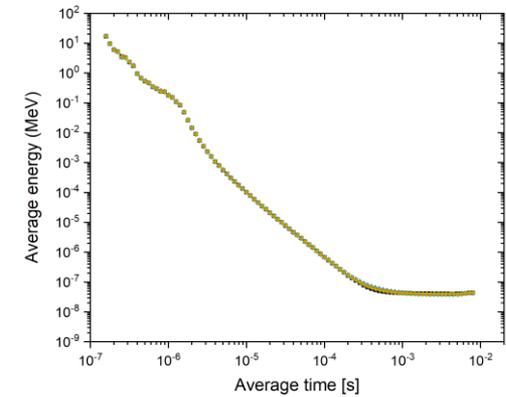
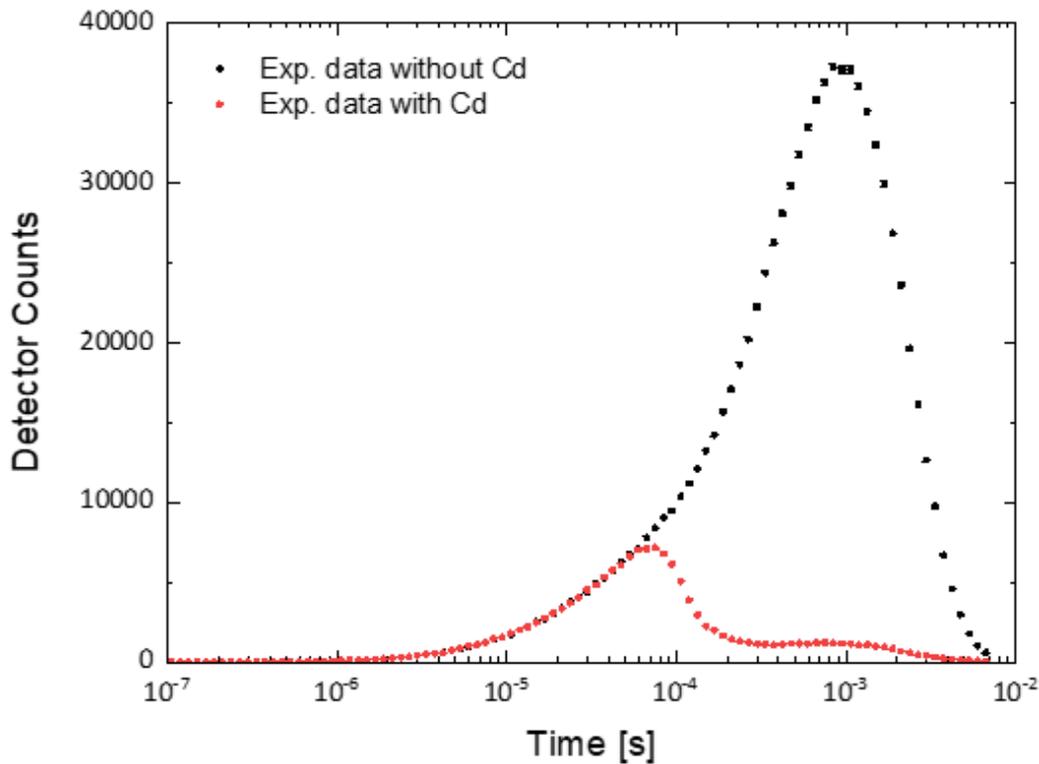
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Independent Reviewer(s)



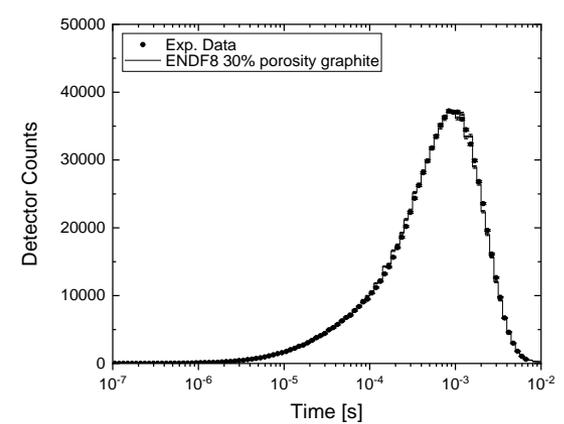
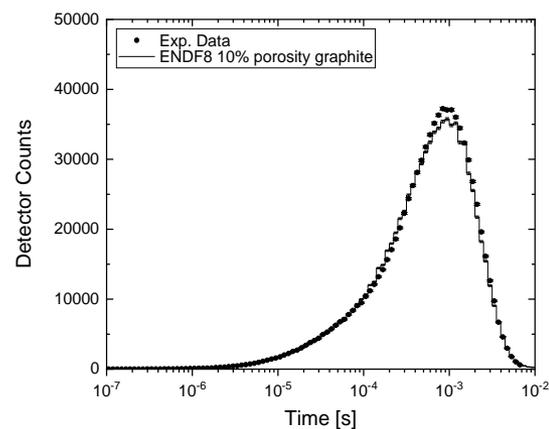
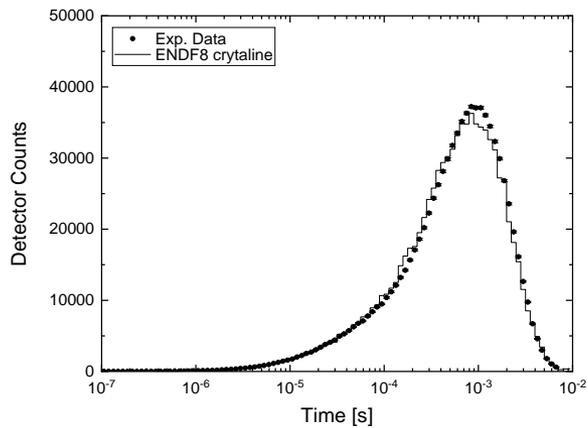
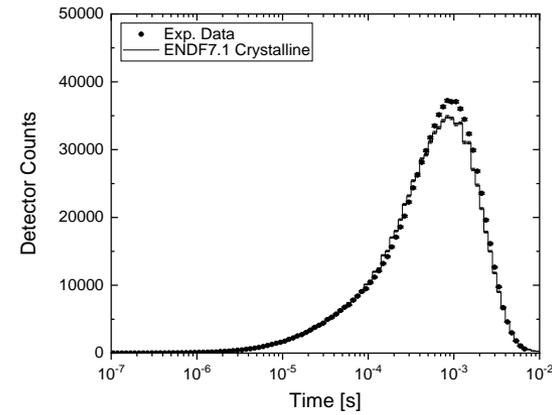
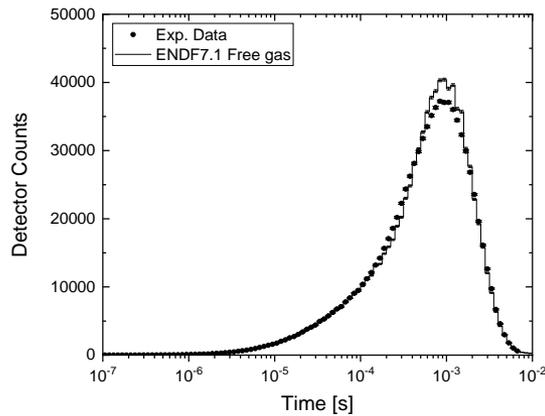
Graphite

Slowing-Down-Time Benchmark



Graphite

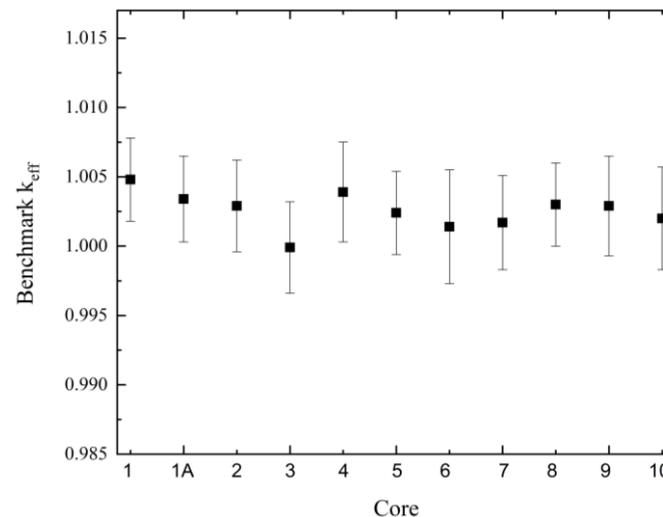
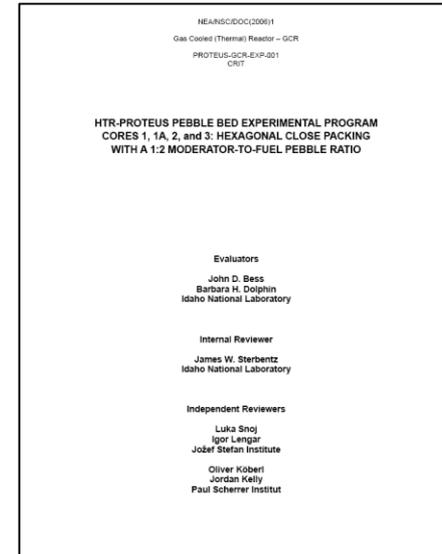
Slowing-Down-Time Benchmark



Graphite

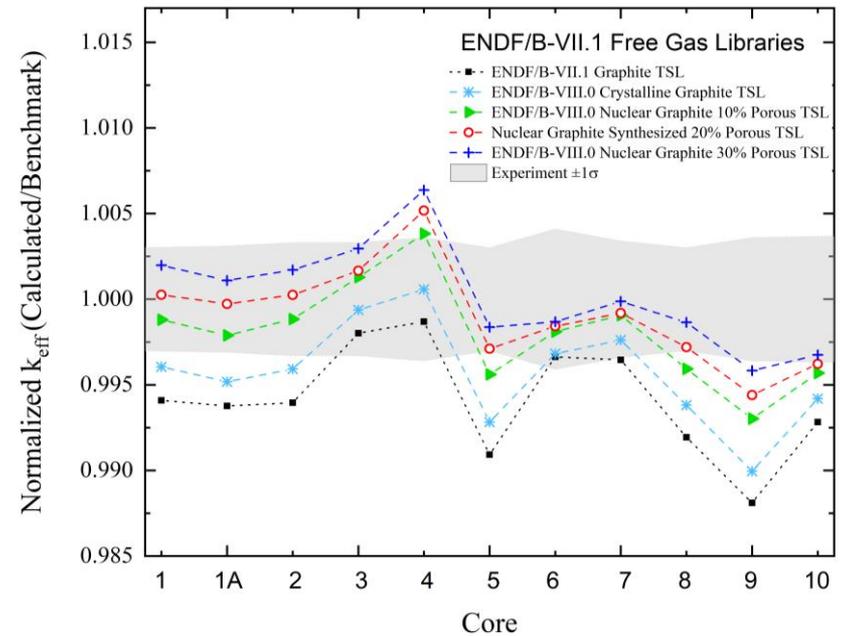
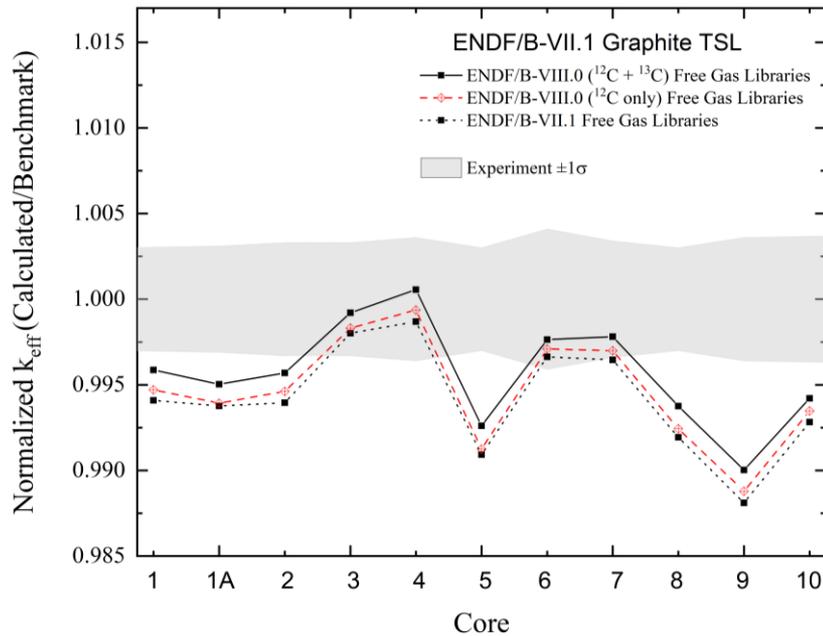
PROTEUS Benchmark

- ▶ International Reactor Physics Evaluation Handbook
- ▶ Uncertainties in k_{eff} range from 0.0030 to 0.0041 for all 11 core configurations
- ▶ Largest contributors to uncertainty include
 - Impurity content in moderator pebbles and radial reflector
 - ^{235}U content
 - Location of upper axial reflector
 - Radial reflector density



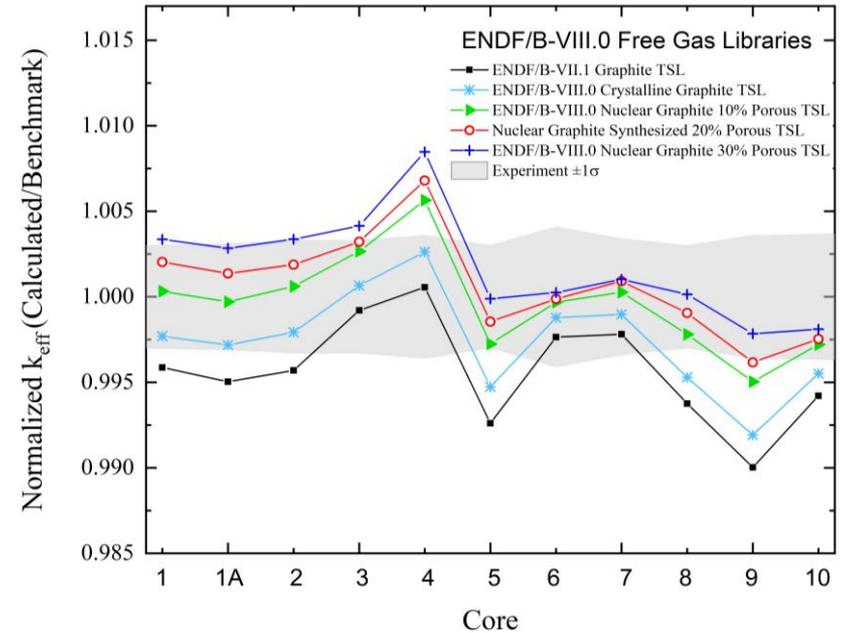
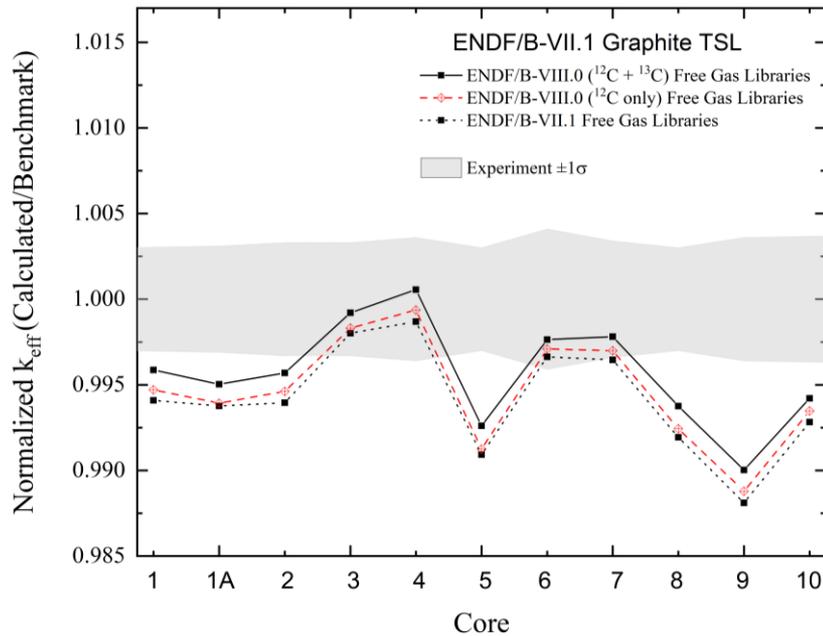
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PROTEUS Benchmark



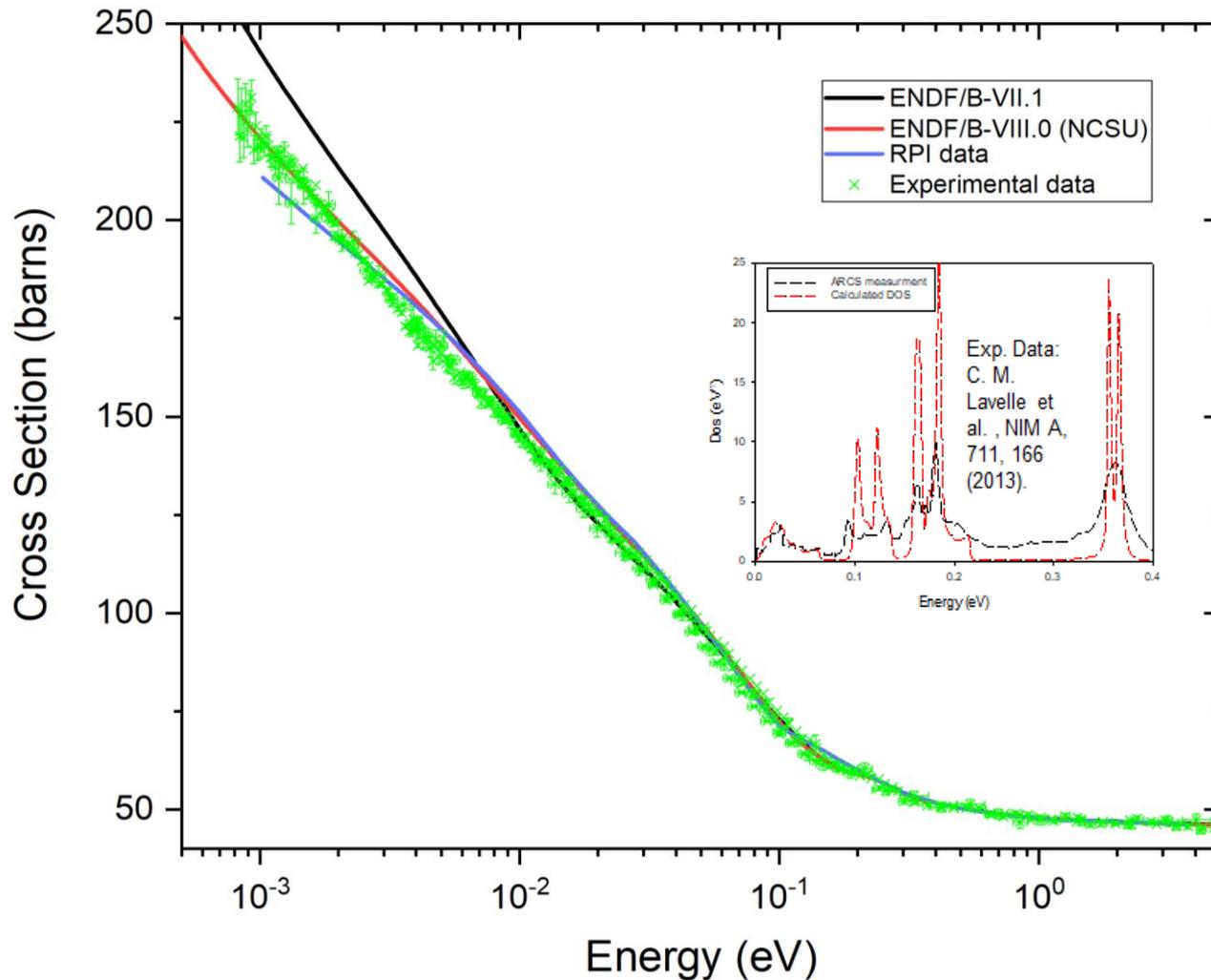
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PROTEUS Benchmark



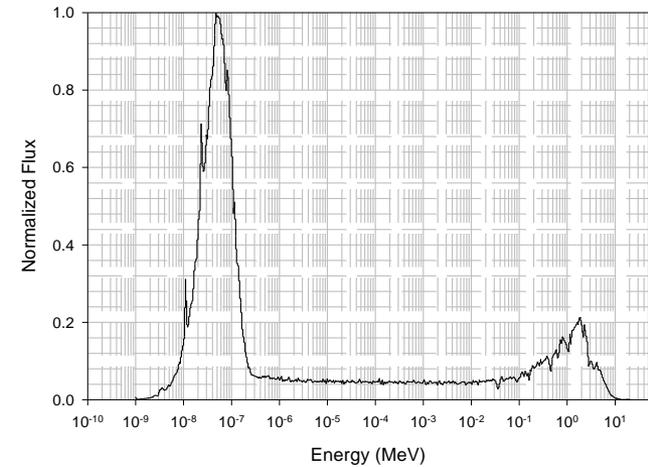
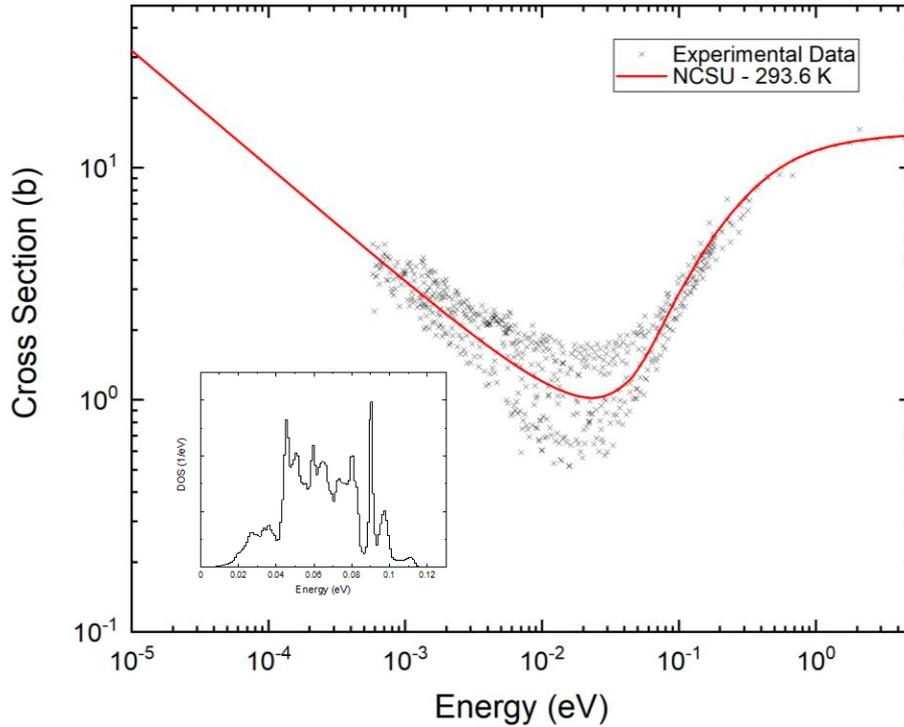
Polyethylene

Validation and Benchmark

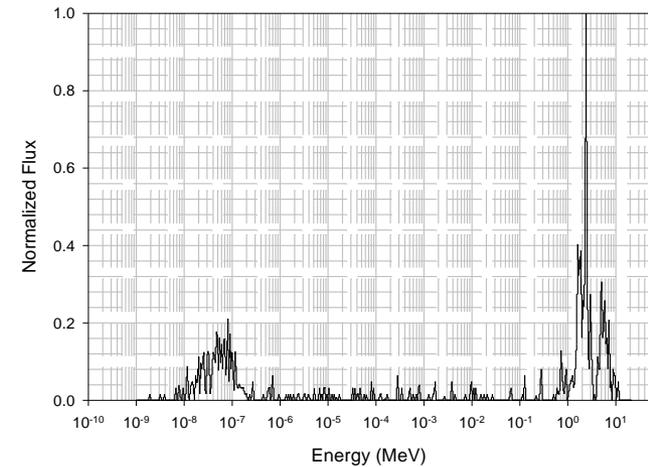


Sapphire (Al_2O_3)

Single Crystal Validation



in

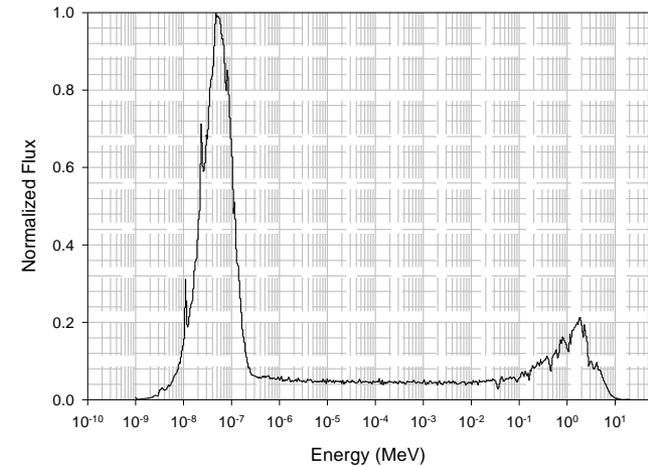
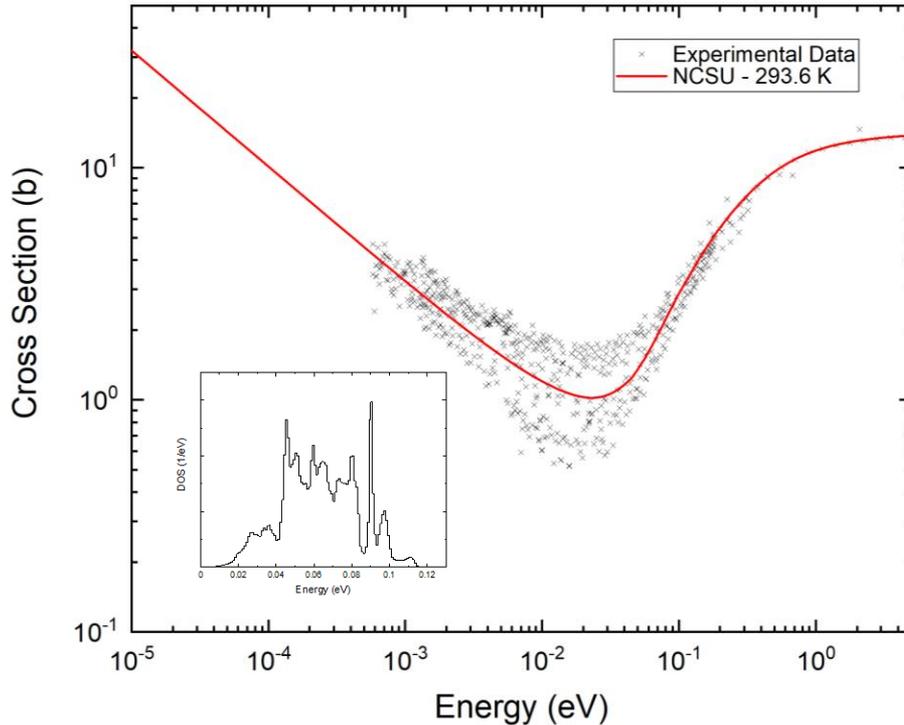


out

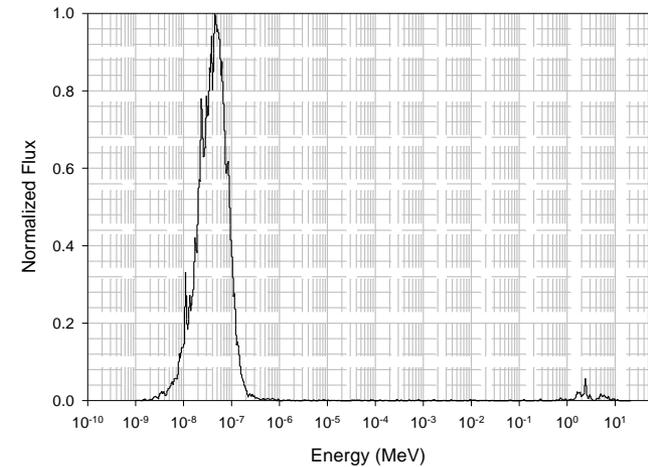
Sapphire (Al_2O_3)

Single Crystal Validation

- Flux verified using gold foil activation and found to agree within 5%



in



out

Summary

- ❑ NCSU graphite SDT ORELA experiment is under development as a benchmark
 - Direct observation of thermal energy region
 - Porous graphite TSL data always improve agreement with measurements

- ❑ Testing of various ENDF/B-VII.1 and ENDF/B-VIII.0 graphite libraries has been performed using the PROTEUS benchmark
 - ENDF/B-VIII.0 introduced an observable change in the carbon cross sections
 - Porous graphite TSL data always improve agreement with benchmark

- ❑ NCSU Polyethylene ENDF/B-VIII.0 TSL improves agreement with total cross section measurements

- ❑ NCSU single crystal sapphire TSL library is based on realistic data
 - Agree with total cross section measurements
 - Demonstrates filter effect experimentally and computationally